EP-1172

Dose calibration of the Tomotherapy treatment planning system based on a static tomotherapy plan

C. Minguez Aguilar[1], D. Sevillano Martinez[1], A. Sánchez Jiménez[1], A. Sanchez-Reyes[1]
[1]*Instituto Madrileno de Oncologia, Medical Physics, Madrid, Spain*

Purpose/Objective: The dose calibration of the tomotherapy system consists on the comparison of the dose calculated by the treatment planning system (TPS) with that measured on a cylindrical Virtual Water phantom for a clinical plan. This method depends on the accuracy of the density curve of the CT as well as on the consistency of the phantom within time. In this work we have developed a static tomotherapy (TomoDirect) plan delivered on a water phantom which allows us to apply the TG-148 protocol on absolute dose measurement of static fields in tomotherapy and compare it with the dose rate output of the machine modelled in the TPS.
Materials and Methods: The plan consisted on the contouring of a rectangular region of interest (ROI) of dimensions 15x40x20 cm^3 to which a density of 1g/cm^3 was assigned. This ROI is placed centered at the isocenter of the machine. Inside, another ROI was contoured at the isocenter in order to use it as a target during the planning process. The dimensions of this ROI were 10 cm long at the transversal direction and 1 pixel in all the other directions. A TomoDirect plan was created with two opposite beams at 0º and 180º gantry angles with a jaw width of 5cm. Full dose and final dose calculations were performed after the first iteration of the optimization process, leading to a plan with two identical and very low modulated beams witha field size of 5x10cm^2. Hence, TG-148 can be applied and k_{Qq0} can be obtained from the method suggested by Thomas et al (Med Phys 2005 May; 32(5):1346-53). The beam at 0º was measured in a rectangular Virtual Water phantom whose geometry equals that of the ROI in the plan. Previously, equivalency between the phantom and water at that point was checked. The results obtained were then compared with the reference dose established during the acceptance of the system and with the expected dose rate calculated based on the energy fluence per ideal open time(EFIOT) included in the TPS.
Results: Difference between dose calculated by the TPS and that measured was within a 0.1% once the dose was corrected by our reference dose rate, which was set during the acceptance of the system. These results suggest that the reference dose rate of our system with a 5x40cm^2field at a1.5cm depth and SSD 85cm should be 837 cGy/min. Given that the EFIOT stored in our TPS has a value of $3.4767x10^{10}$ MeV/$cm^{2,}$ the theoretical dose rate should be 855.6 cGy/min. Therefore, a discrepancy of a 1% was found. Results of this work show that a factor can be established between the dose rate stored at the TPS (EIOF) and that measured in a static reference field. This factor has a value of $4.0124x10^{-10}$cGy.cm^2/MeV.
Conclusions: A direct relationship was obtained between the dose rate data stored in the TPS and that measured in a static beam in reference conditions. The factor obtained between these two parameters could be useful in the calibration of any Tomotherapy unit.

EP-1173

Commissiong and initial experience with dosimetry check, an in vivo volumetric commercial software

M.C. Pujades-Claumarchirant[1], T. Garcia-Martinez[1], J. Gimeno-Olmos[1], V. Carmona-Meseguer[1], F. Lliso-Valverde[1], F. Ballester-Pallares[2], J. Perez-Calatayud[1]
[1]*Hospital Universitario y Politecnico La Fe, Radiation Oncology, Valencia, Spain*
[2]*University of Valencia, Atomic Molecular and Nuclear Physics, Valencia, Spain*

Purpose/Objective: DosimetryCheck (DC) (Math Resolutions) is a commercial EPID based dosimetry software, which allows performing pre-treatment and transit dosimetry. DC provides *invivo* 3D dose which can be displayed on the CT of the patient and provides an independent verification of the treatment, being potentially of great interest due to the high benefits of the *in vivo* volumetric dosimetry, which guarantee the treatment delivery and anatomy constancy. The aim of this work is to study the differences of reference point doses between DC and TPS to establish an accuracy level of the system.
Materials and Methods: We used DC v.3.8 with the EPIDs of two Varian iX. TPS was Eclipse v.10.0 with AAA algorithm. DC employs pencil beam algorithm. DC settings require a series of EPID integrated images acquired with increasing thicknesses of water interposed in the beam. Two specifically designed methacrylate tanks were built for that purpose. To test theresults of DC two phantoms were used: MP1 Water Tank and Solid Octavius 4D cylindrical phantom (PTW). Several plans were generated: (1) Four-field plan with MP1 base in contact with the couch (no air gap); (2) Four-field plan with MP1base 7 cm above the couch; (3) Four-field plan over Octavius 4D; (4) A 360º arc over Octavius 4D. In all cases field size was 10×10 cm^2 with 6 MV and 200 MU per field. Both in pre-treatment mode and during treatment, portal images were acquired in integrated mode for each static field or cine acquisition for arcs. For pre-treatment mode we used SID 105 cm and for transit mode 150 cm. Additional measurements were taken separately with a Farmer ion chamber mounted in MP1 to check TPS calculation.
Results: Agreement between TPS and ion chamber at isocentre for each single field was better than1%. Differences of reference point doses between DC and the TPS are shown in table 1. Total dose differences are less than 2%, but single field contributions may achieve values higher than 5%.

	Plan							
	1		2		3		4	
	Pre	Transit	Pre	Transit	Pre	Transit	Pre	Transit
Total dose difference between DC and TPS at isocenter (%)	-0.6	+1.6	-0.6	+1.2	-1.5	-0.8	-1.5	-0.2
Largest dose difference for the single field contributions between DC and TPS at isocenter (%)	-0.8	+2.6	-0.7	+3.4	-2.3	-5.8	---	---

Table 1. Differences of reference point doses between DC and the TPS.

In transit mode, DC gave unexpected results for fields directly affected by the table. Inplan 1, without air gap, the 180º-field resulted in equal dose at isocenter than 0°, for the same MU. In plans 2 and 3, both with air gap, the 180º-field resulted in even more dose at isocenter than 0°.
DC seems not to consider properly the effect of couch attenuation, especially when there is an air gap between phantom and couch, which could be the case for patients with vacuum mattress.
Conclusions: The tests carried out with simple plans suggest that the accuracy of DC achieves 2% for total dose. However, the study of the contribution from each single field shows greater differences. For off-axis dose distribution and logically for patients this uncertainty will result significantly higher. In any case the possibility of this evaluation and the potentiality of this new system have a very positive impact on improving patient QA. Currently DC system is being used with patients and results and uncertainties associated are under evaluation.

EP-1174

Performance evaluation of 2D and 3D diode array in VMAT verification plan

S. Khachonkham[1], P. Changkaew[1], S. Sakulsingharoj[1], P. Tangboonduangjit[1]
[1]*Ramathibodi Hospital, Department of Diagnostic and Therapeutic Radiology,Bangkok, Thailand*

Purpose/Objective: This study was to evaluate the performance of 2D diode array (MapCHECK2,Sun Nuclear) mounted on the Isocentric Mounting Fixture (IMF) compared with 3D diode array (ArcCHECK, Sun Nuclear) for Volumetric Modulated Arc Therapy(VMAT) plan verification.
Materials and Methods: There were 4 Head-and-Neck (H&N) and 4 Prostate VMAT plans generated by Eclipse V8.9.17 treatment planning system and delivered by Varian Rapid Arc Clinac iX machine. VMAT patient plans were measured in actual beam angles by MapCHECK diode array with 1527 diode detectors at 5 cm water equivalent depth. MapCHECK array was mounted on the isocentric mounting fixture (IMF) and attached to the gantry of Rapid Arc machine. The same VMAT plans with actual beam angles were measured by ArcCHECK with 1386 diode detectors arranged in a spiral pattern with 10 mm sensor spacing. The agreement between VMAT plan (Eclipse calculation) and measurement was evaluated using gamma evaluation with 10% dose threshold and 3% absolute dose difference and 3mm distance to agreement(DTA). The performance of 2D array and 3D array for VMAT plan verification was evaluated by using the percentage of passing point between Eclipse plan and measurement.
Results: For all VMAT plans, the pass rate exceeded 95% using MapCHECK 2D array with IMF and 94% using ArcCHECK. The difference of % passing point between MapCHECK with IMF and ArcCHECK ranged between 0-2 % for each VMAT plan.

Conclusions: Performing patient-specific QA for VMAT plan by using MapCHECK with IMF tool shows the result of agreement between Eclipse plan and measurement comparable with using ArcCHECK 3D diode array.

EP-1175

The matter of IMRT plan QA using gamma pass rate

R. Kawamorita[1], W. Okada[1], R. Nakahara[1], S. Kishimoto[1], K. Ishii[1], T. Nakajima[1], Y. Nishimura[2]
[1]*Tane General Hospital, Department of Radiation Oncology, Osaka, Japan*
[2]*Kinki University School of Medicine, Department of Radiation Oncology, Osaka, Japan*

Purpose/Objective: The purpose of this work is to determine the statistical correlation between 2D IMRT QA passing rates and several clinically relevant, anatomy-based dose errors for per patient IMRTQA.
Materials and Methods: Thirty patients which performed QA of the treatment plan of the VMAT(VARIAN MedicalSystems, USA) with prostate cancer in the past were examined. Each planned with 10 MV linear accelerators (Novalis-Tx; Brain LAB) using a commercial treatment planning system (ECLIPSE; VARIAN Medical Systems, USA) and VMAT. In this study was compared with 2D or volume gamma pass rate and Dose Volume Histogram (DVH), and absolute dose. 2D gamma pass rate analysis was measured by 2D pixel ion-chamber (MatriXX; IBA, Germany). Volume gamma pass rate and DVH were computed by COMPASS MatriXX systems(IBA, Germany). The dose response data measured by the MatriXX(IBA, Germany) was imported to the COMPASS MatriXX systems, and volume gamma and DVH were calculated. The COMPASS MatriXX systems can perform only dose calculation by using imported DICOM plan data and dose response. As for the absorbed dose was compared with 0.6ml Farmer type ion-chamber and COMPASS MatriXX systems. An absorbed dose was compared with mean dose of the same area volume as the area volume measured by ion-chamber of the IMRT phantom, and correlation was investigated.
Results: A variation of 2D gamma pass rate was larger than volume gamma. As a result of performing comparison of 2D gamma pass rate and DVH, absorbed dose error was less than 5% in DVH when 2D gamma pass rate was more than 95% of PTV. However,even if the rectum and bladder were more than 95% gamma pass rate, there was dose error more than 5% in 40% of all measured data. There were correlated with absolute dose measured by 0.6ml ion-chamber and computed by the COMPASS MatriXX systems ($p<0.01$).
Conclusions: Although IMRT Plan QA by means of 2D or volume gamma pass rate were suitable as objective rating of distribution, it was suggested that these were not suitable as clinical assessment of IMRT Plan.

EP-1176

Three years of VMAT patient quality assurance with the PTW seven29 ionization chamber array and Octavius phantom

S. Cilla[1], P. Viola[1], M. Craus[1], F. Deodato[2], G. Macchia[2], C. Digesù[2], M. De Spirito[3], A. Piermattei[3], A.G. Morganti[2]
[1]*Fondazione di Ricerca e Cura "Giovanni Paolo II" Università Cattolica del S. Cuore, Medical Physics Unit, Campobasso, Italy*
[2]*Fondazione di Ricerca e Cura "Giovanni Paolo II" Università Cattolica del S. Cuore, Radiation Oncology Unit, Campobasso, Italy*
[3]*Università Cattolica del S. Cuore, Medical Physics Unit, Roma, Italy*

Purpose/Objective: The introduction of VMAT in clinical routine can be limited for the complexity and time needed in pre-treatment verification, decreasing the number of patients that could benefit. A fast and reliable dosimetric device is then required. Since 2009, over 400 patients have been treated with Volumetric modulated arc therapy (VMAT) at Fondazione di Ricerca e Cura 'Giovanni Paolo II' of Campobasso, Italy. In this study we present the three-years results of our patient specific QA program using the PTW seven29/Octavius system and our institutional guidelines for VMAT delivery.
Materials and Methods: From June 2009 to October 2012, 410 patients were treated with VMAT technique at our institution using Elekta linacs and Oncentra Masterplan TPS. Patients were divided in three groups: (1) 125 patients with high-modulated complex treatments for head-neck, rectal, endometrial and brain tumours, all treated with Simultaneous Integrated Boost strategy using two arcs; (2) 140 patients with prostate and vaginal tumours and (3) 145 patients undergone to radiosurgery or extracranial stereotactic techniques for bone, liver, lung, abdominal and pelvic metastasis, treated by one arc. The absolute doses were measured utilizing the PTW Seven29 ion-chamber array and the Octavius phantom. VMAT plans were recalculated on phantoms representing the Octavius geometry and density; for each arc the doses were measured both on coronal and sagittal planes, for a total of 1070 measurements. Agreement of measured and predicted doses were evaluated using gamma index set at 3%/3mm. Three scalar metrics were evaluated for each measurement: (a) percentage of points with gamma value less than one ($P_{\gamma<1}$), (b) mean gamma (γ_{mean}), and (c) maximum gamma (γ_{max}). Dose measurements at isocenter point were extracted by the seven29 central 0.125 cc ion chamber.
Results: $P_{\gamma<1}$, γ_{mean} and γ_{max} averaged over all treatment sites were 96.8% ± 3.0%, 0.37 ± 0.08 and 1.58 ± 0.70, respectively. For the patients in group (1), $P_{\gamma<1}$, γ_{mean} and γ_{max} were 95.7% ± 3.0%, 0.39 ± 0.08 and 1.90 ± 0.62, respectively. These values reached 98.2% ± 3.3%, 0.35 ± 0.09 and 1.13 ± 0.61 values in group (2) and 98.3% ± 2.3%, 0.31 ± 0.08 and 1.24 ± 0.70 values in group (3). Our local confidence limits for $P_{\gamma<1}$ were determined to be 9.1% over all treatment sites, and 10.2%, 8.1%, and 6.2%, for patients in group 1, 2 and 3, respectively. Mean values and SD of ion-chamber differences between isocenter measured and calculated doses were -0.4% ± 2.8%, -0.7% ± 1.6% and 0.5% ± 2.0% for group 1, 2, and 3, respectively, supplying our local confidence limit of 5.9%, 3.8% and 4.4%.
Conclusions: The PTW seven29/Octavius system allows a fast and accurate dosimetric procedure for VMAT pre-treatment verification, benefiting from all the advantages of ionization chamber absolute dosimetry. Despite the increased complexity in VMAT treatments, our local confidence limits were comparable to those of AAPM TG 119.

EP-1177

Designing, coding and implementing a software solution for daily output QA using an Electronic Portal Imaging Device

S. Buhl[1], P. Andersson[1], U. Bjelkengren[1]
[1]*University Hospital Herlev, Department of Radiophysics, Herlev, Denmark*

Purpose/Objective: In the field of radiotherapy (RT) vast resources are being used on quality assurance (QA) to ensure the most precise treatment delivery. One important parameter to control and monitor is the dosimetric output from the linear accelerator. In recent years at this institute, this has been done by weekly output measurements with an ion chamber in a Perspex phantom. These measurements have been supplemented by daily output measurements using LINACHECK from PTW. However, modern linear accelerators allows for such measurements using the onboard Electronic Portal Imaging Device (EPID). The purpose of this study has been to design, code and implement a software solution for measuring and evaluating the daily output on the Varian iX and Truebeam accelerators using the EPID.
Materials and Methods: Daily warm-up and output measurement test patients were created for each accelerator. These consisted of four fields: two warm-up fields (25 x 25 cm^2, 400 MU, 6 and 15 MV) and two output measurement fields (25 x 25 cm^2, 100 MU, 6 and 15 MV) with the EPID positioned at SID = 100 cm and the measurements carried out by integrating dose over time. To collect reference data and allow for dosimetrically equivalent measurements, the output of all accelerators was measured and adjusted in water to within ± 0.3 % of reference values. Afterwards the integrated image mode of the EPID was calibrated for the clinical used D/R, followed by a dosimetric calibration using a 10x10 cm^2 field and 100 MU. Reference data was then collected using the test patients. All data was exported from the TPS as DICOM files. An algorithm for sorting measurements, calculating output, beam quality, symmetry and plotting in- and cross-line profiles was created using MATLAB. For easy accessibility and quick handling a graphical user interface (GUI) was also coded using the MATLAB GUI editor. Finally the algorithm and GUI were compiled to an executable, allowing the software to run independently of a MATLAB installation using the MATLAB Compiler Runtime (MCR). Several versions of the software was designed, compiled and deployed each targeting a specific personal group with different requirements. All measurements and results were saved to MATLAB data files for storage and easy accessibility.
Results: A lot of energy was used in the design phase of this project which clearly paid out in implementation and evaluation phase, where only minor issues related to the software arose, being primarily coding errors related to e.g. saving data. As a result of this several new versions with error corrections or minor functionality tweaks were deployed over the first months of implementation.
Conclusions: Using MATLAB for creating software to interact with data measured using the EPID exported via DICOM has proven itself possible, easy and reliable. Making in-house software gives the benefits of a highly customizable system alongside complete knowledge and control over algorithms and data handling.

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